

IN THE SPECIFICATION

1. Please replace the paragraph beginning at page 2, line 14, to line 18, with the following:

Korean Patent Laid Open Publication No. 2000-61342 discloses a method of removing polymers remaining on a substrate by successively using a cleaning solution of sulfuric acid (H_2SO_4) and aqueous hydrogen peroxide solution (H_2O_2), a cleaning solution of ~~hydrogen-fluoric~~ hydrofluoric acid (HF) and water (H_2O), and an SC1 cleaning solution. The polymers are generated after a dry etch process for forming a tungsten silicide wiring on the substrate.

2. Please replace the paragraph beginning at page 3, line 8, to line 12, with the following:

Among other advantages, embodiments of ~~the invention~~ the invention provide a cleaning solution that can effectively remove various polymers attached to tungsten wiring without damage to the tungsten wiring and an underlying film. Additionally, the time required for removing the polymers can be greatly reduced, improving the throughput of the semiconductor device.

3. Please replace the paragraph beginning at page 4, line 12, to line 17, with the following:

A cleaning solution according to embodiments of the invention includes sulfuric acid (H_2SO_4), aqueous hydrogen peroxide solution (H_2O_2), deionized water (H_2O), and ~~hydrogen-fluoric acid (HF)~~ HF solution. The ~~hydrogen-fluoric acid (HF)~~ HF solution is prepared by diluting ~~hydrogen-fluoric acid~~ HF with deionized water. The cleaning solution efficiently removes various polymers remaining on a metal wiring formed on a substrate without damages of the metal wiring and an underlying film after a dry etch process is performed to form the metal wiring.

4. Please replace the paragraph beginning at page 4, line 30, to page 5, line 2, with the following:

To meet the above-mentioned characteristics, cleaning solutions according to embodiments of the invention preferably include about 1 to about 10 percent by weight of sulfuric acid, about 0.5 to about 5 percent by weight of aqueous hydrogen peroxide solution,

and about 85 to about 98.5 percent by weight of ~~hydrogen-fluoric acid~~ HF solution.

Therefore, the cleaning solution can effectively remove the polymers generated during a formation of a structure including a tungsten wiring.

5. Please replace the paragraph beginning at page 5, line 14, to line 19, with the following:

Because sulfuric acid can easily corrode the tungsten film pattern, an etched amount of the tungsten film pattern can be controlled in accordance with the amount of the sulfuric acid contained in the cleaning solution. Additionally, the sulfuric acid serves as a catalyst that augments the potential of hydrogen (pH) of the cleaning solution to more rapidly dissolve the ~~hydrogen-fluoric~~ hydrofluoric acid. Hence, the oxygen-containing polymers are more easily removed from the tungsten film pattern.

6. Please replace the paragraph beginning at page 5, line 32, to line 34, to page 6, to line 3, with the following:

The amount of ~~hydrogen-fluoric acid~~ HF solution contained in the cleaning solution varies in accordance with the concentration of the ~~hydrogen-fluoric~~ hydrofluoric acid after dilution with deionized water. The ~~hydrogen-fluoric acid~~ HF solution includes about 1,000 ml of deionized water and about 0.1 to about 2 ml of ~~hydrogen-fluoric~~ hydrofluoric acid. In this case, the ~~hydrogen-fluoric acid~~ HF solution has a concentration of about 50 percent. The cleaning solution preferably includes about 85 to about 95 percent by weight of ~~hydrogen-fluoric acid~~ HF solution.

7. Please replace the paragraph beginning at page 6, line 4, to line 7, with the following:

When the cleaning solution includes less than about 85 percent by weight of ~~hydrogen-fluoric acid~~ HF solution or the amount of ~~hydrogen-fluoric~~ hydrofluoric acid contained in the ~~hydrogen-fluoric acid~~ HF solution is less than 0.1 ml, the cleaning solution may not remove the oxygen-containing polymers.

8. Please replace the paragraph beginning at page 6, line 8, to line 12, with the following:

When the cleaning solution includes more than 95 percent by weight of ~~hydrogen-fluoric acid~~ HF solution or the amount of ~~hydrogen-fluoric~~ hydrofluoric acid contained in the

~~hydrogen-fluoric acid~~ HF solution is more than 2 ml, the cleaning solution may cause damage to the tungsten film pattern and the oxide film pattern although the cleaning solution can easily remove the oxygen-containing polymers and the metallic polymers.

9. Please replace the paragraph beginning at page 6, line 13, to line 16, with the following:

Thus, the cleaning solution preferably includes a ~~hydrogen-fluoric acid~~ HF solution of about 85 to about 95 percent by weight. Here, the ~~hydrogen-fluoric~~ hydrofluoric acid has a concentration of 50 percent and the ~~hydrogen-fluoric acid~~ HF solution includes about 0.1 to about 2 ml of ~~hydrogen-fluoric~~ hydrofluoric acid and about 1,000 ml of deionized water.

10. Please replace the paragraph beginning at page 6, line 33, to line 34, to page 7 to line 3, with the following:

Although the sulfuric acid cannot directly etch the oxide film, the sulfuric acid serves as a catalyst that can more rapidly dissociate ~~hydrogen-fluoric~~ hydrofluoric acid contained in the cleaning solution because the acidity of the cleaning solution increases in accordance with an increase of the amount of sulfuric acid contained in the cleaning solution. When the ~~hydrogen-fluoric~~ hydrofluoric acid is dissociated, it can more easily etch the oxide film and oxygen-containing polymers.

11. Please replace the paragraph beginning at page 8, line 16, to line 21, with the following:

In a process for cleaning polymers that remain on a tungsten wiring, a cleaning solution is provided in a cleaning bath. The cleaning solution includes about 5 percent by weight of sulfuric acid, about 2.5 percent by weight of aqueous hydrogen peroxide solution and about 92.5 percent by weight of ~~hydrogen-fluoric acid~~ HF solution. Here, the ~~hydrogen-fluoric acid~~ HF solution includes about 1,000 ml of deionized water and about 0.1 to about 2 ml of ~~hydrogen-fluoric~~ hydrofluoric acid. The ~~hydrogen-fluoric~~ hydrofluoric acid has a concentration of about 50 percent.

12. Please replace the paragraph beginning at page 8, line 22, to line 27, with the following:

After a dry etch process is performed on a substrate that includes an oxide film and the tungsten wiring, the substrate is immersed in the cleaning solution. In this case, organic,

metallic, and oxygen-containing polymers adhere to the tungsten wiring and the oxide film. The oxygen-containing polymers positioned on an outer sidewall of the tungsten wiring are first removed with the ~~hydrogen-fluoric~~ hydrofluoric acid contained in the cleaning solution. The tungsten wiring includes, for example, tungsten patterns.

13. Please replace the paragraph beginning at page 11, line 11, to line 18, with the following:

Referring to FIG. 7C, in order to remove the polymers (P) attached to the sidewalls of the gate electrodes 110 including the first tungsten film patterns 106a, a cleaning bath including a cleaning solution is provided. The cleaning solution includes about 5 to about 7 percent by weight of sulfuric acid, about 2.5 percent by weight of aqueous hydrogen peroxide solution and about 90.5 to about 92.5 percent by weight of ~~hydrogen-fluoric acid~~ HF solution. In this case, the ~~hydrogen-fluoric acid~~ HF solution includes about 0.1 to about 2 ml of ~~hydrogen-fluoric~~ hydrofluoric acid and about 1,000ml of deionized water wherein the ~~hydrogen-fluoric~~ hydrofluoric acid has a concentration of about 50 percent.

14. Please replace the paragraph beginning at page 11, line 27, to line 30, with the following:

To remove these polymers (P), the substrate 100 including the gate electrodes 110 is immersed in the cleaning solution bath. The oxygen-containing polymers are first removed from the sidewalls of the gate electrodes 110 using the ~~hydrogen-fluoric~~ hydrofluoric acid included in the cleaning solution.

15. Please replace the paragraph beginning at page 13, line 33, to line 32, to page 14, to line 5, with the following:

Referring to FIG. 8E, in order to remove the polymers (P) attached to the sidewall of the bit line 132 having the second tungsten film pattern 128a, a bath receiving a cleaning solution is prepared. The cleaning solution includes about 5 percent by weight of sulfuric acid, about 2.5 percent by weight of aqueous hydrogen peroxide solution, and about 92.5 percent by weight of ~~hydrogen-fluoric acid~~ HF solution. In this case, the ~~hydrogen-fluoric acid~~ HF solution has about 1,000 ml of deionized water and about 0.1 to about 2 ml of ~~hydrogen-fluoric~~ hydrofluoric acid. The ~~hydrogen-fluoric~~ hydrofluoric acid has a concentration of about 50 percent.

16. Please replace the paragraph beginning at page 14, line 29, to line 33, to page 15, to line 2, with the following:

Embodiments of the invention provide a cleaning solution for removing a polymer that includes about 1 to about 10 percent by weight of sulfuric acid, about 0.5 to about 5 percent by weight of aqueous hydrogen peroxide solution, and about 85 to about 98.5 percent by weight of ~~hydrogen-fluoric acid~~ HF solution. The ~~hydrogen-fluoric acid~~ HF solution includes about 1,000 ml of deionized water and about 0.1 to about 2 ml of ~~hydrogen-fluoric~~ hydrofluoric acid, wherein the ~~hydrogen-fluoric~~ hydrofluoric acid has a concentration of about 45 to about 55 percent, and preferably about 50 percent.

17. Please replace the paragraph beginning at page 15, line 3, to line 12, with the following:

Embodiments of the invention also provide a method of cleaning a semiconductor device. After a cleaning solution is prepared, polymers attached to a metal wiring formed on a substrate are removed. The cleaning solution includes about 1 to about 10 percent by weight of sulfuric acid, about 0.5 to about 5 percent by weight of aqueous hydrogen peroxide solution and about 85 to about 98.5 percent by weight of ~~hydrogen-fluoric acid~~ HF solution. The polymers are removed by immersing (or dipping) the substrate into the cleaning solution after a dry etching process is performed to form the metal wiring on the substrate. Then, the substrate is rinsed to remove the remaining cleaning solution and the substrate is dried. In this case, the cleaning solution has a temperature of about 20 to about 30°C and the substrate is immersed in the cleaning solution for about 1 to about 9 minutes.

18. Please replace the paragraph beginning at page 15, line 13, to line 28, with the following:

In accordance with another embodiment of the invention, there is provided a method of forming a structure of a semiconductor device. A substrate is provided. The substrate includes a polysilicon film, a tungsten film, and a nitride film successively formed thereon. Subsequently, a mask pattern is formed on the nitride film and structure is formed on the substrate. The structure includes a nitride film pattern, a tungsten film pattern, and a polysilicon film pattern formed by dry etching the polysilicon film, the tungsten film, and the nitride film. After the mask pattern is removed, polymers attached to a sidewall of the structure formed on the substrate are removed. The polymers are removed by immersing the substrate into the cleaning solution including about 1 to about 10 percent by weight of

sulfuric acid, about 0.5 to about 5 percent by weight of aqueous hydrogen peroxide solution, and about 85 to about 98.5 percent by weight of ~~hydrogen-fluoric-acid~~ HF solution. In this case, the hydrogen fluoric acid solution-~~hydrogen-fluoric-acid~~ HF solution includes about 1,000 ml of deionized water and about 0.1 to about 2 ml of ~~hydrogen-fluoric~~ hydrofluoric acid, wherein the ~~hydrogen-fluoric~~ hydrofluoric acid has a concentration of about 45 to about 55 percent, and preferably about 50 percent. Then, the substrate is rinsed to remove the cleaning solution and dried. Alternatively, a barrier layer is formed between the polysilicon film and the tungsten film.